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IGY BULLETIN

A monthly survey by the U. S. National Committee for the International Geophysical Year. Established by and part of the National Academy of Sciences, the Committee is responsible for the U. S. International Geophysical Year program in which several hundred American scientists are participating and many public and private institutions are cooperating.

THE purpose of the Bulletin is to present current information on the IGY program of interest to scientists and particularly to geophysicists. It is hoped that the Bulletin will be of value to participants in the program by keeping them informed of progress in our own program and in the programs of other countries.

The contents of the Bulletin will include brief articles and reports on projects and experiments in the U. S. program as well as scientific news of activities in other countries, obtained from the Comité Spécial de l'Année Géophysique Internationale (CSAGI).

The Bulletin will attempt to present information in each of the disciplines of the IGY program and in such areas as the Antarctic where regional features are important. The first few issues will provide background for more specific later reports.

The Bulletin can not be comprehensive. The scope of the IGY program precludes this, for the endeavor embraces the efforts of thousands of scientists in the United States and in some sixty nations abroad.

The program in the United States has been developed by American scientists themselves under the auspices of the National Academy of Sciences. To plan and direct the U. S. effort, the Academy established the U. S. National Committee for the International Geophysical Year. The Committee, with its regional committees and specialized technical panels, has cooperated with similar committees of other countries in developing the coordinated, international program and is responsible for the U. S. contribution.

In the development of the U. S. program the National Academy of Sciences has had the cooperation and assistance of hundreds of scientists and many public and private institutions. In any listing of the public institutions assisting in the program perhaps two agencies stand out: the National Science Foundation and the Department of Defense. The Committee has secured Congressional appropriations totalling $39 millions through the National Science Foundation for the specially funded portions of the IGY program, and the Foundation has assisted the Committee in many areas involving the Government. The Department of Defense, aside from contributions of scientists in its laboratories, has provided major logistics support. The Antarctic and the Arctic are examples where appreciable field assistance, involving ships and aircraft, has been provided, while the rocket vehicle aspects of the IGY satellite program afford still another example.

In the course of reporting IGY progress, the Bulletin will relate experiments to institutions and scientists. The contents of articles will be drawn from progress reports submitted to the Academy, correspondence, and discussions. The assistance of participating scientists and institutions is necessary for the preparation of the Bulletin.

—Hugh Odishaw, Executive Director, U. S. National Committee for the International Geophysical Year, National Academy of Sciences.

Antarctic Program

On April 11, 1957 while the Little America IGY Station at Kainan Bay in Antarctica experienced +30°F temperatures, the Amundsen-Scott IGY South Pole Station recorded a world low of −100°F. The unseasonably warm temperatures at Little America caused roofs to leak while heavy wet snow covered up buildings and caches. At the same time, personnel at the South Pole experienced the severest temperatures under which man has ever lived. Despite these conditions, efforts over many months to install USNC-IGY scientific programs at six U. S. Antarctic stations have met with complete success. Scientific observations designed to contribute to the overall International Geophysical Year program will be in full operation prior to the commencement of the Year on July 1, 1957.

Preliminary Operations and Planning

Completion of current test observations at these USNC-IGY Antarctic scientific stations is a major step forward from the voyage of the USS Atka in 1954–55, the first operational aspect of this program. The United States Navy, which had been designated by the Department of Defense to provide logistic support to the USNC-IGY program, sent the USS Atka to Antarctica in the fall of 1954 for a reconnaissance mission to the Ross Sea area, where it discovered that a substantial portion of the Bay of Whales, location of four previous Little America sites, had vanished with the break-off of a huge section of the shelf ice. Kainan Bay, some 30 miles to the east, was discovered to provide the only access to the Ross Ice Shelf in this area and the main USNC-IGY station was recently constructed here. The Atka also attempted to penetrate the ice barrier at several other points on her voyage eastward to the Weddell Sea area, carrying out a reconnaissance of other possible station sites. Some ice studies and oceanographic studies were made, providing data useful for further planning for the USNC-IGY Antarctic program.

With the information made available by the Atka's voyage, as well as by previous Antarctic expeditions, the USNC-IGY formulated final plans for its IGY Antarctic program at the first and second CSAGI Antarctic Conferences held at Paris and Brussels during the summer and fall of 1955. Representatives of eleven national committees coordinated their Antarctic programs at these Conferences, discussing not only the scientific programs to be carried out by each participating nation, but also such matters as the distribution of Antarctic stations and the proposed Antarctic communications network.

Among the resolutions resulting from these conferences was one designating the United States to establish a meteorological center during 1957–59, collecting information from all Antarctic stations, traverse parties, air and surface craft, ocean islands, and stations in South America, Africa, Australia, and New Zealand. This IGY Weather Central, which has since been established at Little America Station, will serve as an analysis center and, for the first time in history, daily weather maps will be prepared for Antarctica. Weather advisories and forecasts important to the planning and execution of operations on land, sea, and in the air will be issued regularly.

1955–56 Operations

During November 1955, ships of Naval Task Force 43 departed from the U. S. to conduct Operation Deep Freeze I. Three icebreakers, three cargo vessels, an oil tanker, and two oil barges proceeded to New Zealand and left there in December to take up picket positions along a flight line to McMurdo Sound. Four long-range planes successfully landed on the ice of McMurdo Sound. The ships of the Task Force then

proceeded to set up two stations on the Ross Sea.

Little America Station was established at Kainan Bay, about 40 miles west along the edge of the Ross Ice Shelf from the site of the former Little America Station, and 70 personnel wintered over during 1955–56 in anticipation of the early seasonal traverse operation needed to establish the Byrd Station in Marie Byrd Land and to finish station construction. Williams Air Operations Facility, at Hut Point on Ross Island in McMurdo Sound, was constructed as a support base for the future airlift to the South Pole, and 93 personnel remained during the winter season.

While construction of stations and unloading of cargo ships were in progress, preliminary work for the operations of the 1956–57 Antarctic summer was begun. A party of light oversnow vehicles reconnoitered a trail from Little America toward the site of the proposed Byrd Station in Marie Byrd Land. The trail reconnaissance party marked 380 miles of their 600-mile route before turning back because of mechanical trouble with their vehicles. Two cache-laying sled swings laid out fuel depots on the trail for use during the establishment of the station which was to commence in October, 1957.

Before returning to New Zealand in mid-January, 1956, the four long-range aircraft based at McMurdo Sound completed reconnaissance flights over the polar plateau following the course to be utilized by aircraft in establishing the Pole Station in the operating season of 1956–57.

Additional activities conducted during Operation Deep Freeze I included a survey of the east coast of Victoria Land for a site for the establishment of a joint New Zealand-U. S. station. One of the icebreakers cruised along the Knox Coast in East Antarctica and the Filchner Ice Shelf on the Weddell Sea to reconnoitre locations for two additional stations. IGY representatives accompanied these reconnaissance cruises, as well as overseeing the unloading and caching of IGY supplies at the present station sites.

Among the materiel transported to the Antarctic by Task Force 43 was equipment to set up and operate the Byrd and Pole Stations. Cached both at Little America and McMurdo Sound, this cargo was to be carried to the station sites early in the 1956–57 operating season.

Scientific Activities —As the objective of Deep Freeze I was the establishment of the two stations in preparation for the IGY, only limited scientific projects were scheduled. However, some observations in cosmic rays, meteorology, oceanography, and atmospheric noise were carried out.

One of the ships was equipped with a cosmic radiation observatory, which operated continuously throughout the expedition. The neutron monitor employed in this observatory threw new light on the position of the magnetic equator, upsetting earlier conceptions of its location.

There was a meteorological observer aboard each ship of the Task Force, and one IGY representative versed in Southern Hemisphere meteorology was present as a consultant. The observers performed standard surface observations of temperature, pressure, winds, clouds, and other phenomena. Several of the ships made upper air soundings and winds aloft observations using balloons, radiosonde transmitters, and radar tracking devices. Special plastic balloons in limited numbers were released for the study of high altitude constant level winds. Other balloon flights of unusual nature were those carrying black bodies for radiation investigations.

A special meteorological unit operated as a weather central throughout the duration of the expedition, receiving reports from all the ships of the Task Force, as well as from land stations and other ships, both in the Antarctic and to the north. This unit drew daily weather maps and issued forecasts for the benefit of parties moving and working in the area.

The concentration of ships in such num-

bers in the Antarctic region permitted oceanographic observations during the course of operations. Continuous echo soundings of the ocean bed were made south from Panama. Bathythermograph observations were made in the Pacific and during passage across the Antarctic Convergence, through the Peru Current, and in the area from the Ross Sea to the Bellingshausen Sea. Other observations included bottom sampling, water and temperature samplings to depth, transparency readings, and color determinations.

A schedule of astronomic positions was set up. At each of these positions, gravity and geomagnetic observations comprised part of the program. At each port of call on the cruise to and from the Antarctic, gravity readings were taken. Other scientific projects conducted during Operation Deep Freeze I included investigation of VLF and LF radio wave propagation and studies of atmospheric noise.

During the winter, IGY representatives at Little America and McMurdo Sound monitored the scientific supplies and conducted geophysical observations. They carried out meteorological studies and tested observational equipment. They also made auroral and meteor studies, perfecting techniques for observing and recording data in advance of full-scale IGY programs. Radar meteor recording apparatus received operational testing.

1956–57 Operations

To coordinate the final effort for the establishment of Antarctic stations, a third international CSAGI conference on the Antarctic was held in Paris during July-August 1956. As during the two previous CSAGI Antarctic conferences, plans for the scientific programs and logistics operations were exchanged and discussed, including the

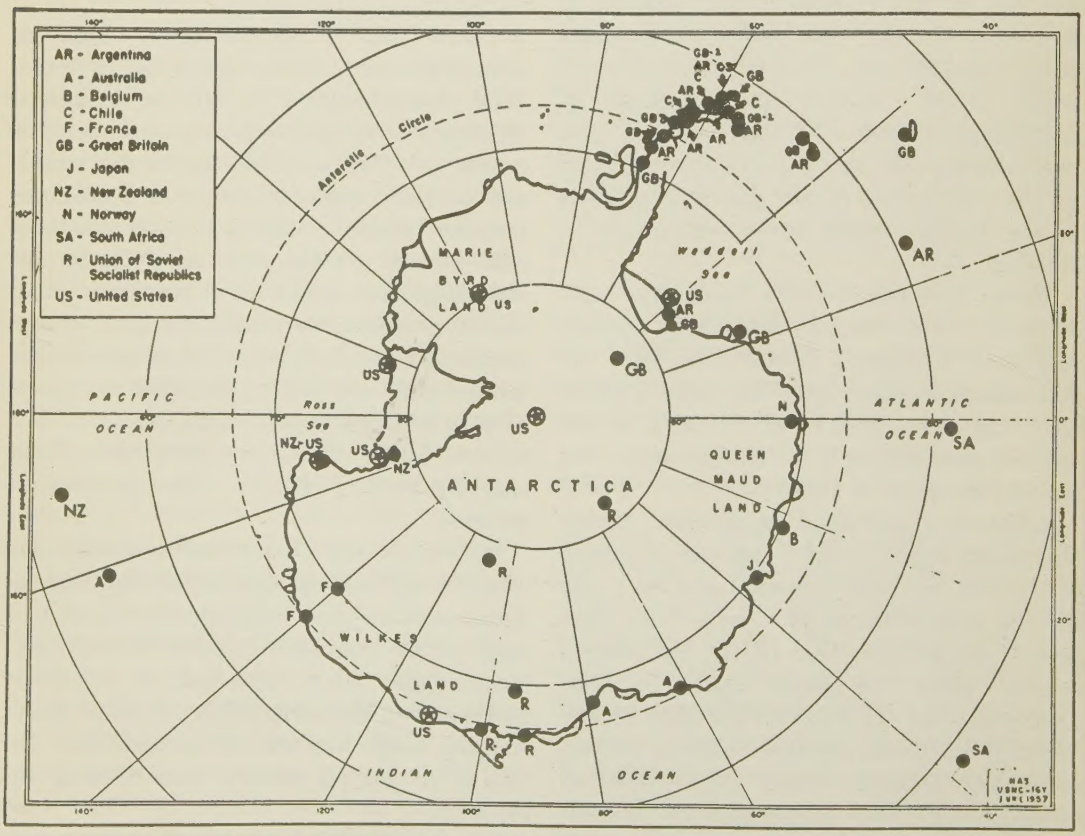

Fig. 1. *Antarctic Stations Planned For The International Geophysical Year*

coordination of the international communication network essential for linking all Antarctic stations and for the operation of the Weather Central.

Although the 1956–57 Antarctic operation formally began with the departure of the icebreakers and cargo ships in late October and early November 1956, activity preceding these events included the processing of 420,000 pounds of scientific equipment and supplies at Davisville, Rhode Island. An orientation program was held during October 1956 for USNC-IGY Antarctic scientific personnel at the Navy Construction Battalion Center, Davisville, Rhode Island. Scientific leaders for the six stations were appointed as follows: A. P. Crary (also Deputy Chief Scientist), Little America Station; G. R. Toney, Byrd Station; P. A. Siple, South Pole Station; C. R. Eklund, Wilkes Station; Finn Ronne, Ellsworth Station; and J. A. Shear for the Adare Station, operated jointly with New Zealand.

Establishment of the South Pole Station—Antarctic operations for the IGY Amundsen-Scott South Pole Station began during October 1956 when Naval and Air Force aircraft landed on the bay ice in McMurdo Sound after a 2200-mile flight from New Zealand. Preliminary reconnaissance flights over the South Pole and Beardmore, Scott and Liv Glaciers resulted in the establishment of an Auxiliary Air Facility at the foot of the Liv Glacier on October 29. Two days later, in −58°F temperature, a ski-equipped Navy airplane with Rear Admiral George Dufek, Commander of supporting Task Force 43, aboard, made the first historic landing at the South Pole. Weather conditions prevented further operations until November 20 when the first airlift of construction personnel and equipment was made. By February 21, 760 gross tons had been dropped during a total of 65 missions. At present 18 men (9 scientific and 9 support personnel) occupy the station. All personnel have been engaged in the completion of the station facilities in temperatures which have already dropped as low as −100°F.

In the installation of scientific equipment for studies of aurora, glaciology, geomagnetism, ionospheric physics, meteorology and seismology, some of the usual problems associated with scientific efforts in the field have been encountered, as well as some unique to this location. The extreme temperatures have caused constant frosting of aurora and airglow domes, which has had to be corrected by experimentation at the station site. Airdrop damage of the ionospheric equipment necessitated the rewiring of several circuits. Lost items have had to be replaced by equipment improvised at the station. In spite of these problems, all disciplines have now installed their equipment and are currently operating on a trial basis.

Establishment of Byrd Station—While great attention was focused on the Pole Station operation, a dramatic attempt was being made to establish a station in the interior of Marie Byrd Land. On November 9 a reconnaissance trial party composed of an experienced Army team supported by Naval aircraft equipped with oversnow vehicles departed from Little America. About 100 miles out on the trail, almost impassable crevasses were encountered which for some time threatened to jeopardize the success of the whole operation. After considerable reconnoitering, and days of patiently bridging crevasses, however, this region was crossed. After five weeks of intensive and hazardous work along the 650-mile route, the train arrived at the site of the Byrd IGY Station. Two heavy tractor trains, along with delivery of 240 tons of fuel and equipment in February by the U. S. Air Force, brought the supplies, scientific equipment and personnel needed to establish the station.

The late construction schedule, the constant wind-blown snow and low temperatures, made the completion of Byrd IGY Station a difficult task, but the 12 scientific and 10 support personnel have successfully completed the erection of buildings and special scientific structures. The meteoro-

logical program is already underway and the aurora, geomagnetic, ionospheric and seismic instruments have been installed, operating on a test basis.

Completion of a 650-mile glaciology-seismology traverse from Little America to the Byrd Station represented a significant achievement, operationally and scientifically. A seismic profile, begun 200 miles out from Little America, has shown that the ice depths increase from 2000 to 7000 feet approaching the station. A profile in the immediate vicinity of the site has determined that this station, which is only 5000 feet above sea level, is located upon 10,000 feet of ice: these data must be regarded as tentative pending more detailed studies.

A route for the 1957–58 IGY glaciological traverse planned at this station has been indicated as follows: Byrd Station to 76°S, 110°W to 77°30′S, 85°W to Byrd Station. The tentative route for the 1958–59 operation will be Byrd Station to 84°S, 110°W to 81°S, 75°W to Byrd Station.

Occupation of IGY Little America Station—With the arrival of the USS Curtiss at Kainan Bay on January 29, 25 IGY scientific personnel occupied the Little America Station. Included among these were Soviet and Argentine meteorologists, who will participate in the work of the Weather Central program. The IGY meteorological program was the first to get under way at Little America with surface and upper air observations beginning January 29.

Special programs are also currently under way. Installation and preparation of the aurora, geomagnetism, glaciological and ionospheric physics equipment are now completed, and data are being obtained. A week's seismic-gravity traverse on the Ross Ice Shelf along the route to Byrd Station has been completed and oceanographic studies of the Ross Sea at the Barrier's edge are being completed. Pit studies have been made at the site of the former deep pit at Little America No. 3.

The IGY Weather Central established at Little America Station, which is to serve as a clearing house for Antarctic weather information, has begun operations. Weather data are being collected on a regular schedule from all Antarctic stations and from nearby ships and aircraft, and from over-land traverse parties. For the first time, a coordinated forecast study of weather data from the far southern latitudes will be available to all nations.

Analyses of recently received data at the Weather Central include surface maps drawn four times daily at 700, 500, and 300 mb., once daily for regions where these data are available. Adiabatic charts have also been completed for these same stations. Preparation of hourly surface charts at 0000, 0600, 1200, and 1800 hours are being completed for stations from which data have been received. It is estimated that full weather collection and broadcasting will commence by June 1 and that analyses broadcasting should begin June 1 if sufficient data are available.

The IGY glaciological traverse party which will operate out of Little America plans to cover the following route during the 1957–58 operation: from Little America to the edge of the Ross Ice Shelf, thence southeast to the Liv Glacier and north to Little America. The proposed route for the 1958–59 traverse is as follows: The party will depart from Little America Station and proceed via the Byrd Station trail to 80°S, 140°W, a point just beyond the heavily crevassed barrier edge. The route will then continue to 77°S, 130°W, to 80°S, 125°W to 83°W, 130°W to 80°S, 140°W and back to Little America Station.

Establishment of Ellsworth Station—A reconnaissance of the Filchner Ice Shelf from Gould Bay to Cape Adams in January 1957, during which ships of the Weddell Sea task group constantly battled heavy pack ice, disclosed no satisfactory station site on which to establish the Ellsworth IGY Station. After exploring the barrier edge which ranged between 150 and 200 feet in height, unbroken for some 200 miles, a site east of Gould Bay was selected for the station and

on January 25 off-loading of cargo began. Off-loading and preliminary construction were completed in the record time of 14 days and the ships departed on February 12. A total of 39 personnel (14 scientific personnel, 14 support personnel and 11 Naval air personnel) have since been engaged in the installation of all scientific equipment for aurora, ionospheric physics and meteorology. Despite the extremely short construction period, installation of all scientific equipment was completed on April 15. Seismic and gravity equipment has been installed in an over-snow vehicle.

In preparation for next year's glaciological-seismic traverse on the Filchner Ice Shelf, the Ellsworth Station Glaciological Traverse for 1957–58 will plan to proceed along the following route: Ellsworth Station to 82° 30′S, 60°W to 78°S 60°W and back to the station. For 1958–59 the route will be Ellsworth Station to 82° 30′S, 20°W to 77° 30′S, 20°W to the station.

Establishment of Wilkes Station—After a reconnaissance of Vincennes Bay, a site on Clark Island was selected on January 29 for the Wilkes IGY station. Off-loading was completed by an amphibious operation and the ships departed on February 17. While 13 support personnel complete the station facilities, the 14 scientific personnel are finishing installation of scientific equipment. The selection of this site is most fortunate; there is an unlimited horizon for aurora observations, and the presence of bedrock makes the location an excellent one for the seismic program. The aurora, meteorology (including two daily balloon flights) and ionospheric physics programs are in full operation and the geomagnetism and cosmic ray programs await only the final preparation of special facilities before recording will begin.

The glaciological team has already established a route to the ice cap and has proceeded to a point 50 miles inland at an altitude of 4000 feet. Ablation and accumulation stakes were set along the trail and snow studies made.

A satellite station was established at a point 50 miles south of the station; here glaciological and meteorological observations are being carried out. This station has been occupied several times within recent weeks. A small glaciological station has also been established on the ramp to the ice cap, at which glaciological movement studies are being carried out. The aurora, ionospheric physics and meteorological upper air programs are currently beginning operations.

Establishment of Adare Station—Cargo for the joint New Zealand-United States Adare Station at Cape Hallett was off-loaded on January 10. By January 29 all buildings had been completed. The 8 scientific and technical personnel, including 3 New Zealand scientists, and 5 support personnel, have been installing the scientific equipment. Three-hourly surface meteorological observations were begun on January 10, 1957, and twice-daily upper air observations began April 1. Observations in the auroral, geomagnetic, seismic and ionospheric physics programs were expected to begin by June 1.

Arctic Drift Ice Station Program

Two drifting stations in the Arctic ice pack have now been established to study oceanography, meteorology, aurora, gravity, ionospheric physics, and ice physics.

Station A is located at approximately 80°N, 159°W, on a section of sea-ice which averages about seven feet in thickness and is about two miles in both width and length. Station B (Fletcher's Ice Island), composed of shelf ice, is about ten miles long, up to

four miles wide, and 140–160 feet thick. It is drifting in the area of 82° 46′N, 99° 30′W, about 510 miles from Thule Air Force Base.

Operational Aspects

Operations for the location and occupation of the two ice stations were conducted by air. The United States Air Force carried on the reconnaissance, constructed the landing facilities, and ferried in both equipment and personnel. Col. Joseph O. Fletcher, Arctic Basin Project Leader for the USNC-IGY, assisted in the reconnaissance for Station A.

The selection and establishment of suitable surface conditions were met with difficulties which attend polar basin activities. Reconnaissance for Station A began early in March 1957, and the first landing on the site finally selected came April 12. Ice conditions in the unusually warm winter required selection of a location somewhat further north than had been anticipated. On April 23, equipment was air-dropped for clearance of a 5000-foot runway, 200 feet wide. Ice hummocks slowed the work considerably, but by May 3—after additional equipment was dropped—an area 3500 feet long, 150 feet wide, had been cleared.

The first landing at Fletcher's Ice Island was made March 7. Construction of a 5000-foot runway began April 5 and was virtually completed April 23. Radio communications during the runway construction period were infrequent due to intermittent blackout conditions. Temperatures at this time dropped to −65°F, causing considerable difficulty with hydraulic lines in construction equipment.

The major airlift to Station A was scheduled for the period May 20–25, 1957. All scientific equipment and personnel were to be ferried to the island at that time. On May 23, a further report stated that the landing field had been completed and flag-raising ceremonies held. The normal complement, including nine scientists, will be about 20 persons. The IGY Station Scientific Leader is Maurice Davidson, of the Lamont Geological Observatory, Columbia University.

Nearly half of two years' supplies for Station B were to be on hand by mid-May. The normal complement there will be approximately the same as at Station A. IGY Station Scientific Leader has been Norman Goldstein, Geophysics Research Directorate, AFCRC.

Scientific Objectives

The contribution of the drifting stations to the overall USNC-IGY glaciology program in the Arctic involves measurement of the annual mass budget of the Arctic sea ice and its relation to total accumulation and ablation at the ice-ocean and ice-atmosphere interfaces respectively. A determination will be made of the annual thermal regimen of the Arctic sea ice and its relation to the net energy exchange across the interfaces. Also there will be determined the respective roles of short- and long-wave radiation; the thermal energy of accumulation, condensation, sublimation, and evaporation; the molecular conduction of heat; and the turbulent transfer of heat in the energy exchange across the interfaces.

Accumulation and ablation of the upper surface of the ice pack will be measured by the combined use of stakes to determine the rise or fall relative to a fixed reference plane within the ice floe, together with measurements of weight differences over given time periods, of vertical cores through the surface snow and ice. Actual procedures must be developed by trial methods at the stations.

Accretion or ablation of ice at the bottom of the ice pack will be determined from a series of cores taken through the ice pack every two or three months.

In other disciplines, aurora will be photographed at both stations by all-sky cameras, and, at Station A, a patrol spectrograph will be used and airglow spectra taken; geomagnetic data will be acquired through use of an Askania Variograph at Station A; incoming and reflected solar radiation will be measured. A vertical incidence sounder will

be utilized at Station B in the ionospheric physics program and at Station A, upper air studies will be made, using balloons. Gravimeter observations will be made at both stations.

Oceanographic data will be gathered on current flow, temperature and salinity at different depths; age determinations will be made on water samples taken from various depths; bottom cores will be taken to permit comparison of Arctic Ocean sedimentation, stratigraphy and marine life with that in other oceans.

Windspeed data will be gathered at six levels, temperatures measured vertically, and surface synoptics prepared. It is also planned to position two automatically recording weather buoys between Station A and Point Barrow. These will gather data on wind direction and speed, air temperature and barometric pressure. They will also be employed in monitoring the movement of ice.

The Earth Satellite Program

The USNC-IGY earth satellite program is designed to provide an observatory in the upper atmosphere over a wide range of latitudes and for an extended period of time. Besides functioning as an observatory by virtue of its instrumentation, the satellite itself may be observed from the ground for several additional scientific purposes.

Satellite Rocketry and Launching

The satellite will be launched from Patrick Air Force Base at Cape Canaveral, Florida, in an easterly direction so as to take advantage of the earth's rotation to gain added velocity. A 72-foot, three-stage rocket will be used; it will be finless, using internal controls for guidance. The vehicle design, construction, and launching aspects of the program are responsibilities of the Naval Research Laboratory and its contractors; prime contractor is the Martin Company of Baltimore.

The first stage will have a thrust of 27,000 lb and will propel the system upwards, tilting gradually until at burnout the vehicle will be at an inclination of approximately 35°. The first stage will be discarded at burnout and the second stage will take over.

The second stage will contain the guidance system for the flight control of all three stages: guidance during the active flight of the first two stages, guidance during the coasting of the second stage, and guidance for the initiation of the third stage.

The second stage motor, gimbal mounted like the first, will drive the vehicle to an altitude of about 140 miles and then coast some 700 miles to attain the desired altitude of between 250 and 300 miles. At this altitude, after the nose cone has been ejected, a pinwheel array of jets will spin the vehicle. The third stage will then quickly consume its solid fuel in impelling the satellite into its orbit at the necessary orbital velocity of 18,000 miles per hour.

Physical Description and Orbit

The first satellite will be spherical, about 20 inches in diameter, and will weigh approximately 21.5 pounds. About a quarter of this weight will be required for the satellite shell and internal structure; the remainder will be left for the various instruments, including the telemetering system.

The satellite's orbit will permit it to resolve about the earth in an apparent latitude range of about 35° on either side of the equator. The satellite will have an elliptical orbit with perigee about 200–300 miles and apogee 800–1500 miles above the earth.

Orbit Computation

Radio tracking and teams of visual observers will gather preliminary data on the satellite's location in space. These data, gained during the early revolutions of the satellite, will be fed into high-speed electronic computers. The results will establish an approximate satellite orbit, permitting observers throughout the world to train their instruments on the satellite, and also permitting precision Schmidt cameras to make photographic measurements of the satellite's position.

The second step, which involves both the radio and photographic observation stations, will be to process the extensive subsequent data in order to compute the orbit accurately.

The third phase of these programs involves the analysis of the precise orbit data. Such analysis will yield important scientific information in a number of areas.

Radio Observations and Measurements

Radio observations will employ a system developed by the Naval Research Laboratory. It is a precision, several-component system known as Minitrack. The expected precision of observations is about three minutes of arc under normal conditions with improvement to a precision of 20 seconds of arc for observations at small zenith angles and for night operation.

The Minitrack system makes use of established radio interferometric principles. It utilizes a transmitter of minimum size and weight within the satellite to illuminate pairs of receiving antennas at ground stations. By comparing the path length from the transmitter to one antenna with the path length from the transmitter to a second antenna, it is possible to locate the satellite in its orbit, determining its angular position by radio phase-comparison methods. Similar measurements with another set of antennas, at right angles to the first set, help to fix the satellite accurately.

The pattern of the Minitrack antennas will be fan shaped. At satellite heights, the beam will be several hundred miles wide. In this way a chain of stations stretching from latitude 35° north and south could intercept the satellite at each passage. Station sites have been located at or near Washington, D. C.; Savannah, Georgia; Havana, Cuba; Antigua, British West Indies; Quito, Ecuador; Lima, Peru; Antofagasta, Chile; Santiago, Chile; San Diego, California; and Woomera, Australia.

Optical Observations and Measurements

Optical observations of the satellite will be effected by several programs. The most precise optical observations will be made using a modified Schmidt camera developed for the optical tracking program of the Smithsonian Astrophysical Observatory. Continuous strip film will simplify the problem associated with following the satellite. To provide accurate timing, crystal clocks calibrated against WWV will give a signal for photography simultaneously with the satellite. Time must be read to the millisecond.

A modified Schmidt camera of much better optical quality and field than the standard Schmidt camera has been designed by James G. Baker. Strip film of approximately 55 mm width will be used to eliminate the need for film molding on the spherical focal surface and to permit rapid change of film so that short exposures may be made in twilight where the sky brightness may approximate that typical during full moon conditions. The field covered will be about 5° x 30°.

Optical tracking stations are planned in New Mexico, U. S. A.; Florida, U. S. A; Olifantsfontein, South Africa; Haleakala, Maui, Territory of Hawaii; Tokyo, Japan; Curacao, Netherlands Antilles; Cadiz, Spain; Shiraz, Iran; Arequipa, Peru; India; Villa Dolores, Argentina; Woomera, Australia.

The Schmidt camera system requires that the path of the satellite be known initially to a precision of about three degrees so that

preliminary sighting positions can be established. The radio tracking system will give this information, but in the unlikely event of radio failure in the satellite a network of organized volunteer observers will provide protection.

Although a particular individual will obviously have difficulty in viewing the satellite, trained teams of observers can undertake a satellite acquisition program.

Ground Station Experiments

An important area of scientific inquiry during the earth satellite program can be explored by means of careful analysis of orbital data acquired by ground stations, both radio and optical stations. The following are four areas of study that may be conducted:

(1) *Air density*—Very little is presently known about the density of the upper atmosphere. From the geometry of the satellite's course and observations of its flight, calculations can be made of air drag.

(2) *Geodetic determinations*—Observations of the satellite's orbit should furnish valuable data on the oblateness of the earth. In addition, improvements in the map of the world may be derived from simultaneous as well as synchronized fixes upon the satellite if its orbit is determined accurately enough. These observations would supplement the measurements planned in the IGY latitude and longitude program.

(3) *Ionospheric measurements*—The radio signal from the satellite will be refracted on passing through the ionosphere. The more oblique the passage, the more pronounced will be the refraction and the resultant displacement of the altitude of the satellite as indicated by this radio observation. Comparison of this apparent altitude with that derived from the computed orbit, based on many observations, will indicate the amount of ionospheric refraction and permit calculation of some of the electrical charge characteristics of the ionosphere.

(4) *Composition of the Earth's crust*—Methods should become available to derive information on the distribution of the earth's mass and possibly even the composition of its crust from observed perturbations in the satellite's orbit, provided the orbit is precisely known.

Satellite-borne Experiments

In addition to the experiments described above, the satellite affords a unique tool for observations of atmospheric and cosmic phenomena not directly susceptible to measurements on the earth. Many valuable ideas for possible satellite experiments have been presented by many private and public laboratories. The following experiments represent those now contemplated for satellite flights.

(1) *An experiment to measure the ultraviolet radiation from the sun at approximately 1,216 Angstroms*—This wavelength, the Lyman alpha line, is emitted by hydrogen, and represents a large part of the total ultraviolet radiation received from the sun.

Solar ultraviolet and x-radiation contribute most of the energy which is absorbed in the upper atmosphere. The energy of these radiations is first detected as ionization, affecting long-distance radio transmission, and causing other interesting phenomena such as airglow. Some of this energy eventually finds its way to lower levels in the atmosphere, where it affects the weather and climate. Solar ultraviolet data for any two-week period would be extremely useful, but should the period of the experiment include a solar flare or some other abrupt disturbance, the data would be of very great scientific interest. The Naval Research Laboratory is preparing this experiment.

(2) *A cosmic ray experiment*—The nature and origin of cosmic rays is not well known, nor is it easy to make measurements of their characteristics because of the screening effect of the earth's atmosphere. A Geiger counter in an IGY satellite will be used to measure the total incidence of cosmic rays at levels well above the atmosphere, without respect to charge, energy, or direction.

This simple experiment, prepared at the

State University of Iowa, will be the first long-continued measurement of cosmic rays over a wide area above the atmosphere of the earth. It will also establish a basis for future experiments, possibly involving more elaborate equipment and satellites extended over a greater range of latitudes.

(3) *An experiment to measure the earth's magnetic field*—The satellite can obtain synoptic data of the earth's magnetic field in space, sampling a wide range of altitudes in the range between perigee and apogee.

The scientific significance of magnetic field measurements lies in their ability to test the various hypotheses which have been made about streams of charged particles in the upper atmosphere and hence the nature of the field in the earth's high atmosphere. The Naval Research Laboratory is conducting this experiment.

(4) *An experiment to measure the terrestrial energy balance*—The principal energy input to the earth consists of radiation received from the sun. Some of this radiation is diffusely reflected by clouds, the remainder is converted to heat and is ultimately reradiated as diffuse radiation in the far infrared portion of the spectrum.

Since weather receives its heat input from the sun and exhausts by radiation to space, a better knowledge of these inputs and outputs would seem to be the most fundamental data one could expect to obtain.

Four special temperature sensing elements will be mounted, probably one at the end of each of the satellite's antennae. They will be coated with materials sensitive to radiation of various wave lengths, permitting three of the sensors to distinguish among, and measure, the solar visible, the reflected solar visible and the earth's infrared emission. The fourth sensor will incorporate a device sensitive to direction so that the effect of solar radiation in a directional beam can be distinguished from diffuse radiation. This experiment is being developed at the University of Wisconsin.

(5) *An experiment to observe the cloud cover of the Earth*—A technique which is likely to be important for possible future weather patrol satellites is presently being prepared at the Signal Corps Engineering Laboratories. This technique approximates a television picture of the cloud cover as contrasted with land masses and sea areas. Although the resolution of the system is expected to be only about six to thirty miles, a world-wide picture of the earth's cloud cover will be extremely valuable for studying weather phenomena.

(6) *Environmental experiments*—In addition to the 'hard-core' experiments listed above, a number of secondary environmental experiments are being prepared by the Naval Research Laboratory for inclusion along with one or more of the primary experiments. For the first satellite, the following are planned: surface and interior temperatures, skin erosion by micrometeorites and gas molecules, the number of encounters with micrometeorites above a predetermined minimum energy level, a rough measure of leakage rate in the event of puncture by a meteorite.

Secondary experiments are also planned for other satellites. In connection with the geomagnetic experiment, an extremely lightweight inflatable sphere has been developed. This sphere will be as visible as the original satellite and is expected to give air-drag data. The expandable satellite may well prove to be a valuable technique for possible future satellite work at higher altitudes. The National Advisory Committee for Aeronautics is preparing this experiment.

Status Report: Seismology, Gravity and Longitude Latitude

The status of activity in each IGY area, approximately as of the opening of IGY, will be presented in the first three issues of the *Bulletin*. The status of the programs in seismology, gravity and longitude and latitude determinations is summarized below; other fields will be summarized in the next two issues.

Seismology Program

Studies of the Antarctic crustal structure will be made through the recording of earthquake waves. Stations for recording such waves have been set up at the Amundsen-Scott South Pole Station, Byrd Station, Cape Adare and on the Knox Coast at Wilkes Station, and all equipment has been installed. The station seismographs were procured by the U. S. Coast and Geodetic Survey; more specialized instruments were supplied by Lamont Geological Observatory and California Institute of Technology. In addition, portable equipment—supplied by Lamont Geological Observatory, Boston College, University of Wisconsin, and California Institute of Technology—is in use for study of the ice thickness and the underlying terrain. The first traverse, 650 miles from IGY Little America Station to IGY Byrd Station, has already been completed. The resulting seismic profile, begun 200 miles from Little America Station, showed ice depths increasing from 2000 to 7000 feet as Byrd Station was approached. In the immediate vicinity of Byrd Station, which is 5000 feet above sea level, ice thickness was found to be 10,000 feet.

Sea exploration is also planned as part of the USNC-IGY seismology program. Seismic refraction and reflection measurements will be made by Lamont Geological Observatory in traverses running almost the full length of the eastern and western Atlantic in coordination with vessels from Woods Hole Oceanographic Institution; the National Institution of Oceanography, England; Argentina; Brazil; and other South American countries. Sediment thickness and crustal layering will be determined. In the southeast Pacific, seismic exploration will be carried on by the Scripps Institution of Oceanography. Two vessels will be used for this work which will be performed in conjunction with studies of the deep currents. The cruise for this purpose is scheduled for November 1957–March 1958.

Simultaneous land and sea measurements are involved in the program of seismic exploration of coastal structures. In addition, measurements in sharply contrasting terrain—very high mountains and neighboring low lands—will be carried on in the Andes. A crustal strain seismograph has been installed in Santiago, Chile, and a second installation is practically complete at Huancayo Geophysical Observatory, Peru, constructed and installed under the supervision of Hugo Benioff, California Institute of Technology. These will be used to collect data on the accumulation of strain, whose release causes earthquakes.

Data on long period and other surface seismic waves will be collected by a widespread network of instruments. One long period instrument is now installed at the Coast and Geodetic Survey Seismological Observatory in Honolulu, and instruments have been shipped to the Belgian Congo and Trinidad. Nine additional installations are scheduled.

In the Arctic and North Atlantic Ocean regions, as well as several western Pacific islands, the U. S. Coast and Geodetic Survey will conduct studies of wave velocities, the location of earthquakes, crustal structure, and the relation of microseisms to storms. The stations for these studies are Thule, Greenland, and, in the Pacific, the islands of Guam, Truk and Koror. The stations at Guam and Truk have been in operation

since May 1956, and the installation at Koror was to have been completed in May 1957. A seismograph is being installed at Palmyra Island in cooperation with Scripps Institution of Oceanography.

Gravity Program

Overall objective of the IGY gravity program is to extend and complete the world network of gravity measurements. The number of pendulum bases for control purposes is being increased and gravimeter measurements extending from these bases intensified. The U. S. program is designed to aid materially in eliminating the serious gap in the international network of gravity observations which extends over most of the Southern Hemisphere and the polar regions.

Pendulum and gravimeter measurements have already been made in the past year—under the direction of George P. Woollard, University of Wisconsin—at Antarctic stations in order to establish base points for traverse teams using gravimeters. These teams will also measure ice thickness in support of seismic measurements. The Antarctic program will further contribute to studies of the topographic relief and isostatic compensation of the continent as a whole.

Some 12 pendulum and 40 gravimeter stations had been occupied by May 1957. The pattern ultimately to be achieved calls for occupation of stations in high latitudes and the establishment of meridional lines between the polar regions using Gulf compound quartz and Invar pendulums. These lines of observations will extend southward from Thule following the east coast of North and South America; southward from Shemya following the east Asiatic Coast through Australia to the Antarctic; southward from Hammerfest to Bodo where connection may be had with existing measurements; and southward from Barter Island to Fairbanks, where connection with existing measurements occurs. Lines of pendulum measurement already exist from Fairbanks, Alaska, to Mexico City, Mexico, and from Oslo, Norway, to Capetown, South Africa, established under the auspices of the Cambridge Research Center of the Air Force.

Gravimeter measurements will be made to establish ties between key pendulum base points, to establish regional networks of gravity observations where these are lacking or doubtful, and to integrate existing data into the world network.

The program calls also for improved determination of the rigidity of the earth at the tidal periods of approximately 12 and 24 hours. A highly sensitive recording gravimeter for the measurement of the tidal movement of the earth has already been used at various locations. It is sensitive to about one billionth of the value of gravity at the earth's surface, corresponding to a change in distance from the center of the earth of about one-eightieth of an inch. Using this instrument, which he helped develop, Louis B. Slichter, Director of the Institute of Geophysics, University of California, recorded a maximum amplitude of tidal motion of the earth of about four inches in November 1956 in Honolulu.

Submarine-based gravity measurements are projected, depending on the availability of submarine time. J. Lamar Worzel, Associate Director of the Lamont Geological Observatory, Columbia University, reports that a prototype instrument for this program constructed by Anton Graf, Munich, Germany, performed so well that, with suitable stabilized platforms now being developed, it should be adaptable for use on surface vessels—a development that would revolutionize the study of gravity at sea.

Latitude and Longitude Program

Objectives of this program include more precise determination of latitudes and longitudes, improved time determinations, and measurement of irregularities in the earth's rotation. A concomitant program centers on determinations of the moon's position in order to measure the moon's

motion for uniform time, detect variations in the earth's speed of rotation, and determine the geodetic relationship of widely-spaced points. The shape of the earth will also be studied in this program.

William Markowitz, Chairman of the USNC-IGY Technical Panel for the program, expected to receive Danjon impersonal astrolabes from France prior to July of this year. These, together with crystal clocks, will be used for latitude and longitude observations at the U. S. Naval Observatories at Washington, D. C., and San Diego, California, and at the U. S. Coast and Geodetic Survey Astronomical Observatory at Honolulu. Coordinates for these and other stations set up in the world-wide IGY program will be determined with anticipated errors of only a few feet. Map errors now range up to several hundred feet, and the positions of some islands are uncertain by as much as a mile.

Special cameras designed by Dr. Markowitz for moon-position determinations have been shipped to about 20 astronomical observatories around the world and are expected to be in operation by July of this year. The Markowitz camera takes a simultaneous exposure of the moon and surrounding stars, holding the moon's image fixed relative to the stars. This permits finding the position of the moon relative to the stars much more exactly than by other methods. Several observations of the moon on a single night by a station will determine the position of that station with reference to the center of the earth. From the positions obtained for a sufficient number of stations, the figure of the earth may be constructed.

Reports from Other Countries

Unless otherwise noted, the source of the following reports is the CSAGI IGY NEWS. Inquiries should be directed to Vice Admiral Sir Archibald Day, CSAGI Co-ordinator, 6 Avenue den Doorn, Uccle, Belgium.

Australia

The annual relief of the Australian National Antarctic Research Expeditions was recently completed.

New equipment installed at Macquarie Island includes a Dobson Ozone Spectrophotometer, an all-sky camera for automatic auroral photography, 'whistler' recording equipment and an additional cosmic ray meson telescope. Some modifications to the ionosphere sounder are being made without interruption of routine soundings.

Meteorological, geomagnetic and seismic observatory routines are continuing as previously.

The observing program at Mawson has been expanded through the installation of an ionosphere sounder, equipment for tracking meteor trails for upper wind determinations, an all-sky camera, phototheodolites for parallactic photography of the aurora, and a twelve counter cosmic ray neutron monitor, the records from which will supplement those from the two large meson telescopes. An active program of glaciological work and ice depth determination has been introduced.

Meteorological, seismic and geomagnetic observatory work is continuing at Mawson. Equipment for recording rapid magnetic fluctuations is being installed.

A new station, named Davis, was established at 68° 34.6′S., 77° 58.6′E. The program will cover meteorology, geology and operation of an automatic all-sky camera for auroral photography.

It is expected that all equipment will be operating before the end of March. Active participation in the IGY program at all three stations is assured.

Sweden-USA: Cosmic Ray Program

The Swedish ship *Lommaren* of the Trans-Atlantic Steamship Company, carrying the cosmic ray neutron monitor provided by the U. S. National Committee, under the direction of Martin Pomerantz of Bartol Research Foundation, is now making its second voyage to South Africa. The *Lommaren* left Göteburg, Sweden, on October 13, 1956, bound for Capetown, South Africa, with the monitor aboard, after preparatory testing of the equipment in the Baltic Sea. This was the first of several voyages that it will make in connection with studies of the geomagnetic latitude dependence of the cosmic ray intensity. These studies are related to the location of the geomagnetic equator.

A preliminary estimate of the location of the equator was made at the longitudes of crossing. However, at the most significant time—the crossing of the equator—a solar disturbance caused a world-wide decrease in cosmic ray intensity (a Forbush type decrease). Using data from other neutron monitor stations, however, it will be possible to make the necessary corrections for a more accurate location of the equator.

No worldwide disturbances of the cosmic ray intensity were reported at the time of the monitor's re-crossing of the equator on the return from its first voyage.

A continuation of the experiments with the same type of equipment is being carried on and is expected to extend throughout the IGY.

United Kingdom: Rocket Research

The first of the British Skylark rockets was fired at Woomera Range on February 13, 1957. The main object was to gain experience of its performance and at this firing no scientific observations were made.

As part of the British contribution to the IGY, research groups from five Universities and University Colleges, working under the auspices of the Royal Society and the Royal Aircraft Establishment of the Ministry of Supply, are cooperating in a program of scientific research, using specially designed instruments to be carried to heights up to 90 miles in the Skylark rocket, which will carry a payload of 100–200 lbs.

At the February firing, the 80-foot rocket launcher was depressed as far as possible so that the rocket flew a long flat trajectory. The reason for this approach is that the rocket has no form of guidance control. It possesses only three fixed stabilizing fins so that it is, in fact, a simple dart with a motor. Once launched it relies upon the built-in stability of the design to keep it going along the desired trajectory.

The scientific program is designed to investigate the pressure, density and temperature of the upper atmosphere, winds at very great heights, the ionosphere and night airglow. Various methods of measurement of each parameter will be used.

Among other things, it is proposed in connection with determining the sodium constituent of night airglow to produce sodium yellow fluorescence artificially by the ejection from the rocket of an ignited mixture of sodium and thermite at a chosen height. Special apparatus will be carried in the Skylark to obtain information on the E and the two F layers of the ionosphere by the use as probes of radio signals transmitted and received at ground level. Further experiments are planned for the measurement of air pressure, density and temperature at heights up to 80 miles, from readings of gauges mounted on the nose of the rocket itself.

Further information is obtainable direct from the Royal Society, Burlington House, Piccadilly, London, W. 1., England.

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